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A MODIFICATION OF THE H-133 GROUND COMMUNICATIONS HEADSET FOR USE IN INTENSE NOISE ENVIRONMENTS

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FOR THE COMMANDER

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Detailed technical information and instructions are provided for a simple modification of the Air Force standard H-133 ground communications headset for use in intense noise environments at levels of 135 dB (SPL) and higher. This modification involves the replacement of the conventional H-136 earphone with a miniaturized receiver mounted on a custom molded insert earplug. An adaptor box-line potentiometer is fabricated to provide manual control of the level of the speech signal at the ear of the wearer. The modified H-133 communications headset has been utilized at selected Air Force bases by ground maintenance personnel who rate the hearing protection and voice communications performance as excellent.

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SUMMARY

Detailed technical information and instructions are provided for a simple modification of the Air Force standard H-133 ground communications headset for use in intense noise environments at levels of 135 dB (SPL) and higher. This modification involves the replacement of the conventional H-136 earphone with a miniaturized receiver mounted on a custom molded insert earplug. An adaptor box-line potentiometer is fabricated to provide manual control of the level of the speech signal at the ear of the wearer. The modified H-133 communications headset has been utilized at selected Air Force bases by ground maintenance personnel who rate the hearing protection and voice communications performance as excellent.

PREFACE

This developmental research was accomplished in the Biological Acoustics Branch, Biodynamics and Bioengineering Division, Armstrong Aerospace Medical Research Laboratory, Aerospace Medical Division (AMD). The inhouse effort was accomplished by Dr. Charles W. Nixon and Mr. Henry C. Sommers, deceased, of the Biological Acoustics Branch under Project 7231, "Biomechanics in Aerospace Operations", and a core research task currently identified as Task 723121, "Biocommunications", Work Unit 72312104, "Bioacoustics and Biocommunications Research". Capt Ann Prohaska of the Biological Acoustics Branch provided invaluable assistance in the preparation of this document.

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INTRODUCTION

Air Force aircraft ground maintenance operations produce noise environments that exceed 140 dB sound pressure level (SPL) re 20 uPa at some personnel locations. Safety and voice communication problems can occur when noise environments exceed levels in the region of 135 dB even with maximum available sound protection equipment. These problems may be relieved with improved sound protection and voice communications effectiveness provided by a modification of the standard Air Force ground communications headset. This modification is reasonably simple and can be accomplished locally with a relatively small resource expenditure. This document provides detailed information and instructions for implementing the terminal equipment modification. The specific components listed herein have been utilized successfully, however substitution of equivalent items has also proven satisfactory.

CURRENT AIR FORCE TECHNOLOGY

The current Air Force standard ground communications headset-hearing protector (H-133) with the M-101 microphone

and microphone-noise shield, is designed to provide satisfactory operation in broad band noise fields of about 135 dB and below. This design goal can be satisfied cnly when the hearing protector-communications headset system is in a state of good repair and is both fit and worn properly by ground crew personnel. Field experience indicates that the H-133 unit does not provide adequate hearing protection or voice communications in noise fields well below 135 dB when it is worn improperly and/or is in poor working condition.

The H-133 headset was developed some time ago, however it does represent the state-of-the-art in passive earmuff type hearing protectors. Although no direct efforts are planned to redesign or improve the H-133 headset it may benefit in the future from two technology programs now underway.

1. Digital Audio Distribution System (DADS). The tri-service DADS program that is underway will develop a new standard digital intercommunication system. This program also includes requirements to provide the DADS system with new terminal equipment with comfort, sound protection and speech communications capabilities that are better than those of current equipments. Technologies developed to provide these increases in performance capabilities may also

be applicable to communications equipment for ground maintenance operations.

2. Active Noise Reduction (ANR). An ANR system that reduces low frequency noise at the ear by electronic means is being developed for application in Air Force headsets and helmets. The ANR system is expected to provide as much as 20 dB active noise reduction at frequencies below about 2000 Hz. The active noise reduction obtained is added to the passive attenuation of the headset in which the ANR unit is installed and should result in significant improvements in both hearing protection and voice communications. Aircraft ground maintenance voice communications systems are targeted for the mature ANR technology. However, neither the DADS nor the ANR system is sufficiently developed at this time to be included in the Air Force inventory.

OPERATIONAL PROBLEMS

Air Force aircraft ground maintenance and flight line noise environments at levels of 130 to 135 dB and higher create problems for personnel wearing the H-133 ground communication headset. Depending on the particular unit, how well it is fit to the user, and the duration and level of the exposure, personnel may experience (a) increased risk of hearing loss due to excessive noise exposure at the ear, (b) degraded voice communications due to the acoustic

masking effect of the noise and to temporary hearing loss, both of which increase the probability of communication errors and (c) reduced daily time on the job in noise due to limitations imposed by the daily allowable noise exposures defined in AFR 161-35, Hazardous Noise Exposure [1]. Noise exposure problems associated with the use of the H-133 headset in these very intense noise environments have already been identified relative to some ground operations with aircraft that include the F-15, F-16, T-33 and the F-111.

A secondary problem may be created when personnel who have access to a manual gain control attempt to overcome the degraded voice communications in the noise by increasing the gain of the speech signal to improve communication performance. It is possible for the gain of the signal to be adjusted to such a high level that the speech signal, instead of the noise, constitutes an additional or even the primary risk to hearing.

GENERAL TECHNOLOGY AND APPLICATION

It is well established that the reception of voice communication in noise with conventional electroacoustic transducers and noise shields is generally maximized with (a) a good noise excluding earmuff and (b) communication equipment with the signal coupled to the ear via some form

of well-fitting ear insert device. In a "Study and Investigation of Specialized Electroacoustic Transducers for Voice Communication in Aircraft" (AD document 212459 and Appendices 1 to 6, AD 212210)[2] reported in 1960, use of ear insert unit coupling of the communication signal to the ear under a noise excluding helmet is identified as the most effective approach to this problem.

The technology underlying the approach reported in this document indicates that the relative performance of communications headsets in which conventional receivers are mounted in earmuffs strongly depends on the internal volume of the units. The earmuff requires a large internal volume for good sound attenuation effectiveness. However, the communications receiver requires a small volume for effective coupling of the communications signal to the ear. The concept described herein takes advantage of these contradictory volume requirements, integrating both into the modification, to provide an acceptable system.

This technology concept has been reduced to practice for the specific operational problem with ground maintenance voice communications in intense noise. It involves a simple modification of the standard H-133 ground communication headset that results in substantial improvement in both hearing protection and voice communications in severe noise environments. The modification utilizes a custom molded ear

insert earplug attached to a miniature receiver which replaces the H-136 earphones and is integrated with and worn under the H-133 earmuff. The modified system retains the large internal volume required for good sound attenuation. Additional sound attenuation is obtained because two hearing protectors are being worn, the earplug in combination with the earmuff. Voice communication is more effective because of the improved signal-to-noise ratio resulting from the increased noise exclusion and a stronger communication signal with the miniature receiver driving only the very small volume of air between the earplug and the eardrum membrane. A simple plug-in adaptor box (line potentiometer) allows the incoming signal to be adjusted to an acceptable level at which efficient communication may be maintained.

SPECIFIC APPLICATION

This technology has been applied to various aircraft maintenance noise problems at locations such as Edwards, McClellan and March AFB's and its superiority over the H-133 ground communication units in these special situations has been proven.

BENEFITS TO THE AIR FORCE

The most direct benefits apply to AF ground maintenance and flight line personnel and involve increased safety and

effectiveness. Specifically, these include (a) improved hearing protection, (b) satisfactory voice communication, (c) retention of personnel in high level noise for longer duration work periods each day and (d) features such as less discomfort, increased confidence in voice messages, and the like are also realized.

MODIFICATION INSTRUCTIONS

Table 1 contains a list of the components used in the modification illustrated in the various figures. Although the list is relatively current, prices and nomenclature are subject to change. Any equivalent component that is compatible with the equipment operation is acceptable. In addition to the equipment modification, individual custom molded earplugs must be obtained for the ears in which communication will be accomplished.

Custom Molded Ear Inserts

Custom molded ear insert earplugs are fabricated from individual impressions of the ears in which the devices are to be worn. When the hearing sensitivity of the user is not essentially the same in both ears, the custom molded earplug should be used in the better hearing ear. The impressions, which should be taken only by qualified and trained personnel, are sent to a fabricator who constructs from the

impression a mold that is used to make the actual earplug. The earplug must be identified to the fabricator as a "communication insert with a snap ring adaptor" to accept hearing aid or button type receivers. Otherwise, the custom molded earplugs provided by the fabricator may be constructed without a speech communication channel and without the snap ring required to accept the miniature receiver.

It is critical that the custom molded unit be well fit and that the portion that extends into the ear canal of the wearer be sufficiently long to accomplish a good acoustic seal. Substantial amounts of hearing protection may be lost when the canal portion of the earplug is too short to provide an adequate acoustic seal. It is not advisable for inexperienced personnel to attempt to take the ear impressions. Experience has proven that custom molded units obtained in this way are often uncomfortable, poorly fit, provide inadequate sound protection and are costly because they must be reaccomplished to obtain an acceptable molded earpiece. Also, it is strongly recommended that the custom molded earplugs be fabricated from the soft, fleshlike materials (silicone, for example) instead of the hard acrylics in order to achieve good sound protection and comfort.

Some AF installations have the capability to provide custom molded ear insert devices. However, most installations may find it necessary to procure these units from reliable vendors. Advice regarding vendors and the making of impressions of ears for use in fabricating the custom molded earplugs may also be obtained from the local Audiology Clinic or from AMD, AAMRL/BBA, 255-3607 (Autovon 785-3607).

Terminal Equipment Modification.

The modification of the H-133 communication headset may be accomplished by completing the following steps.

Step 1. The earmuff sponge filler inserts and the H-136 earphones are removed from each of the earcups (see Figure 1). The two wires (red and green) are disconnected from the earphones using a very small Allen wrench. Neither of the H-136 earphones is replaced.

Step 2. The two wires from the earcup to which the insert receiver will be attached are then connected to one part of the mating plug. In this report Mosely connectors were used and the wires connected by tightening the slotted retaining screws. (See Figures 2 and 3). The two wires from the other earcup are insulated from one another with

tape, wire caps or "heat shrink" insulation material and replaced in the earcup with the sponge filler inserts.

Step 3. The cable from the Telex receiver is cut to a length of about 12 inches. The leads are soldered to pins or are stripped and tinned and then fit into the other part of the mating plug. In the Mosely connector they are held in place by tightening the slotted retaining screw. (Figures 2 and 3).

Option 1. Any two-conductor connector (mating plug) can be used to join the Telex receiver to the wires of the H-136 receiver. The Mosely connector was an arbitrary choice made at the time of the development of the modification.

Option 2. The two-conductor connector can be omitted from the modification and the two wires removed from the H-136 receiver (red and green) connected (soldered) directly to the wires from the Telex receiver.

Step 4. The telex receiver is "snap" attached to the custom insert earmold (Figure 3) by the standard snap ring connector. An assembled modified system is shown in Figure 2 prior to attachment of the Mosely connector to the existing receiver mounting post inside the earcup.

Step 5. A 1/8" hole is drilled into the center of the Mosely connector which is assembled and attached to the inside of the earcup on the existing receiver mounting post, using a #4, 5/8" self-tapping screw. The earcup filler materials are replaced in the earcup over the connector.

Adaptor Box-Gain Control

The level of the communication signal at the ear is substantially greater with the ear insert system than with the conventional H-136 receiver for the same gain setting. An adaptor box (line potentiometer), with appropriate plugs, is inserted inline in the communication system before the earmuff system to allow the user to adjust the signal to an appropriate level. In practice, this means reducing the level of the signal to within a comfortable listening range. Ideally, the signal should be adjusted to the lowest level that will provide satisfactory voice communication in the specific noise environment. Pictorial views of the adaptor box are presented in Figures 4 and 5.

The electronic schematic for the adaptor box is presented in Figure 6. The diode circuit constitutes a safety feature that limits the transmission of very intense signals through the box. This adaptor network can be assembled in accordance with the schematic and the illustrations using the appropriate components listed in

Table 1. The physical characteristics of the box are not critical and can be any reasonable size or shape, however, the electronic characteristics must be satisfied to insure proper operation. The open adaptor box is shown connected to the H-133 headset system in Figure 7.

BINAURAL HEARING OPTION

The basic H-133 headset modification scheme involves the use of a custom molded earplug in one ear and a standard insert earplug in the other. There is an option to this procedure that may be desirable in some situations.

This option utilizes two custom molded insert earplugs and miniature receivers, one in each ear. The modification is the same as for a monaural system except that custom molded earplugs must be obtained for both ears and the two miniature receivers connected to the wires in the respective earcups. Donning and doffing the headset system will require that the receiver wires be pushed inside each of the earcups. The use of two insert receivers should provide a slightly better speech signal to the wearer than is experienced with one insert receiver. There are no other changes in the modification procedure.

UTILIZATION: WEARING THE DEVICE

Some practice may be required in donning and removing this system which is probably the least satisfactory feature of the H-133 headset modification. This procedure involves positioning or resting the earmuffs near the ears, properly inserting the custom molded earplug in one ear and the standard insert earplug in the other and then donning the earmuffs. Two approaches to this donn/doff procedure have proven to be satisfactory. (a) The earmuff headband can be placed behind the neck, as shown in Figure 8. The custom molded unit is then positioned in the appropriate ear (visible in Figure 8). A standard insert earplug (V-51R or EAR) is inserted in the opposite ear. The earmuffs are then placed in position over the ears as shown in Figure 9. The wire from the insert receiver must be placed entirely inside the earcup and can be "tucked in" using a finger under the earcup. If the earcup cushion rests on the wire an acoustic leak may occur resulting in a loss of low frequency sound protection. (b) Some personnel prefer to rest the earcups on the cheeks in front of the ears instead of positioning the unit behind the neck. The remainder of the procedure is identical to that described in (a).

The same procedure, in reverse order, is followed to remove the units from the head. It would be desirable to utilize a receiver wire that is permanently coiled so that it would automatically retract during donning of the earmuff

and thus decrease the possibility of air leaks resulting from the cushion resting on the wire.

ACOUSTIC PERFORMANCE

The amount of sound attenuation provided by the modified H-133 headset is presented in Table 2. The mean minus 2 standard deviations and the C-A values correspond to the noise descriptors utilized in AFR 161-35 to estimate allowable daily exposures. The spectra and levels of aircraft ground maintenance noises vary, however the allowable exposure time should be significantly increased with the modified unit over that allowed with the standard stock item. An analysis conducted in an F-111A prep area indicates that an improvement with the modified over the standard unit increases the allowable exposure time by a factor of approximately four.[3]

The levels of the speech spectrum from the modified custom molded earplug are greater than those from the H-133 headset spectrum by 10 to 20 dB at frequencies of 1000Hz and below and by 5 dB or less up to 4000Hz. This relative increase in the speech spectrum and marked improvement in reception is achieved with the gain control adjusted to the maximum setting. However, excellent voice communications are achieved with the potentiometer adjusted to a low gain

setting; the higher gain settings should not be used continuously.

CONCLUSIONS

This report describes a ground communication headset modification that will improve hearing protection and voice communication in intense noise environments at a reasonably small cost. The critical factors to insure the increased performance are (1) an ear insert type coupling of the communication signal and (2) good noise excluding earmuffs. Although these conditions can be satisfied in other ways, the components and procedures described herein have proven successful in operational situations.

REFERENCES

1 "Hazardous Noise Exposure", U. S. Air Force Regulation 161-35, April 1982.

2 "Study and Investigation of Specialized Electroacoustic Transducers for Voice Communication in Aircraft", AD Document 212459 and Appendices 1 thru 6, AD Document 212210.

3 Sommer, H. C. and J. F. Rose, Jr, "Noise and Speech Levels Associated with the F-111A Prep Area, McClellan AFB", AMRL TR-72-2, May 1972.

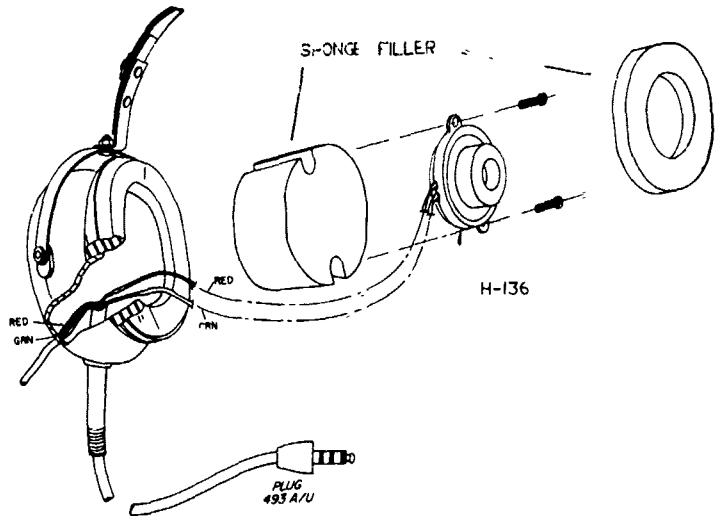

FIGURE 1

AN EXPLODED VIEW OF AN H-133 HEADSET EARCUP SHOWING THE SPONGE FILLER INSERTS, THE H-136 EARPHONE AND THE RED AND GREEN WIRES

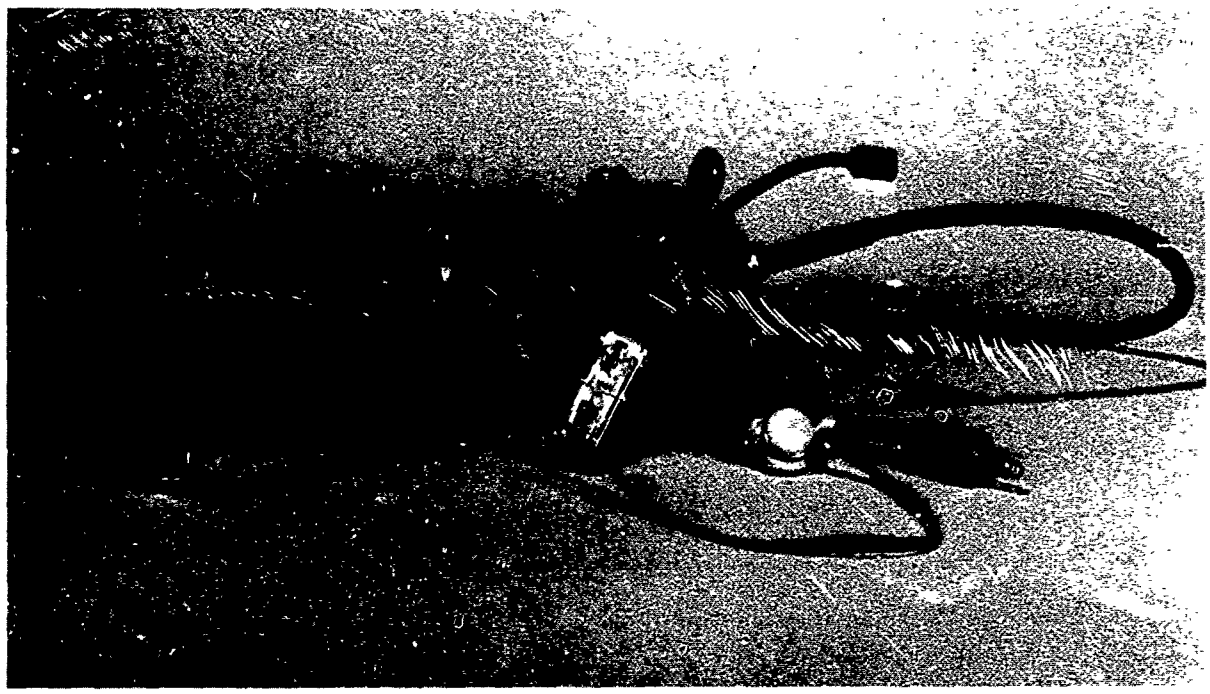

FIGURE 2

PHOTOGRAPH OF THE H-133 HEADSET SHOWING THE MATING PLUG USED TO CONNECT THE WIRES FROM THE H-136 EARPHONE TO THE MINIATURE RECEIVER.

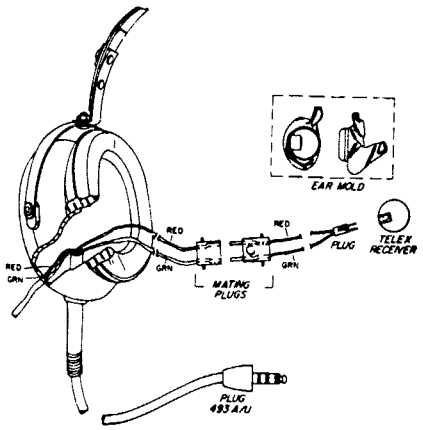

FIGURE 3. EXPLODED VIEW OF THE MODIFIED WIRING FOR THE MINIATURE RECEIVER.

FIGURE 4. SCHEMATIC ILLUSTRATION OF THE ADAPTOR BOX-GAIN CONTROL UNIT.

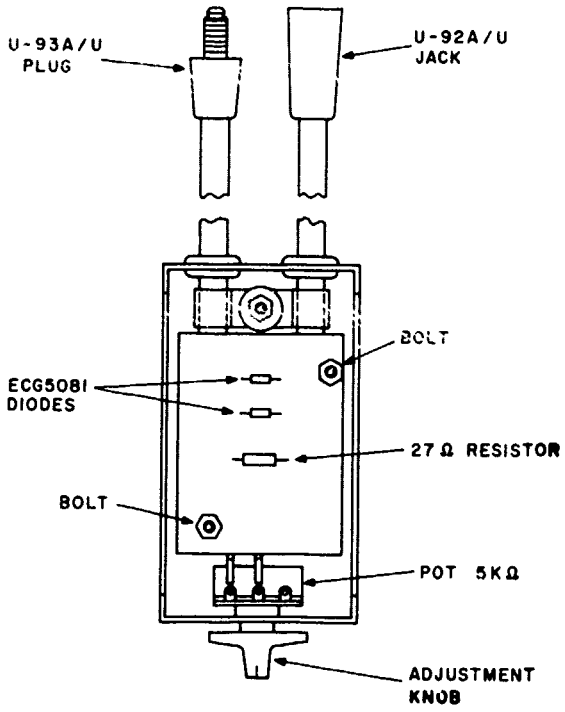

FIGURE 5

PHOTOGRAPH OF THE FABRICATED ADAPTOR BOX WITHOUT COVER.

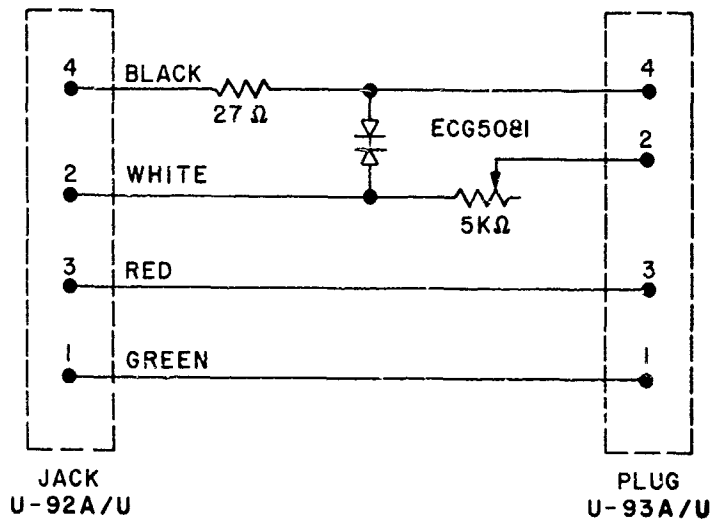

FIGURE 6

ELECTRONIC SCHEMATIC FOR THE ADAPTOR BOX.

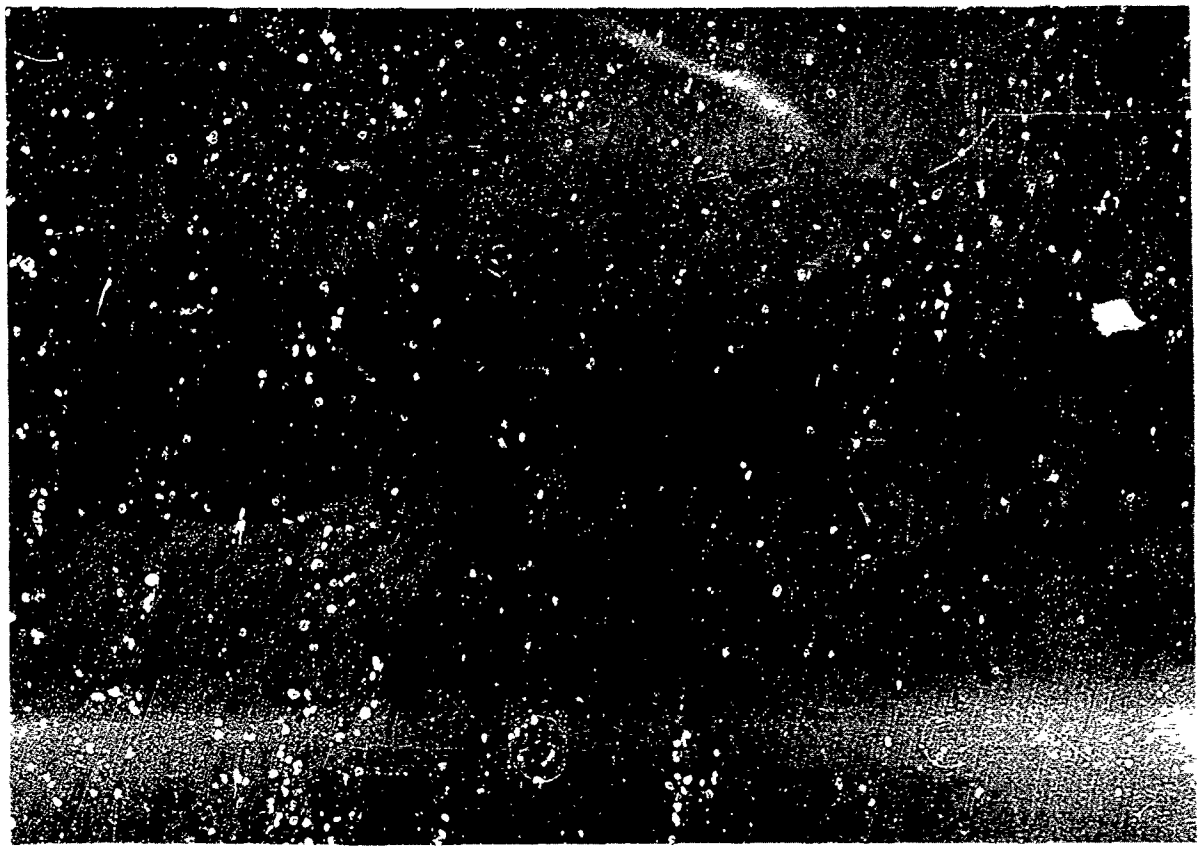

FIGURE 7

PHOTOGRAPH OF THE COMPLETED H-133 MODIFICATION AND OPEN ADAPTOR BOX BEFORE COMPONENTS ARE REPLACED INTO THE EARCUP.

FIGURE 8. THIS PHOTOGRAPH ILLUSTRATES THE PREFERRED POSITION OF THE MODIFIED H-133 HEADSET WHILE INSERTING THE CUSTOM MOLDED AND STANDARD EARPLUGS.

FIGURE 9. PROPER POSITIONING OF THE COMPLETED MODIFIED H-133 HEADSET.

TABLE 1

Component Parts List *

Item	Description	Manufacturer and Model	Number Required	Cost
1.	Receiver, "Button" Type	Telex, 15 ohm	1	3.00
2.	Cable	Telex, CMT-92 60013-013	1	2.65
3.	Connector	Mosely, 301	1	0.75
4.	Connector	Mosely, 311	1	0.75
5.	Potentiometer	HMP 5000 ohm (Centralab RY4NAYSD502A)	1	2.15
6.	Diode	ECG 5081	2	0.85
7.	Resistor	27 ohm	1	0.25
8.	Plug	U-93 A/U 5935-00-66420626	1	2.73
9.	Jack	U-92 A/U 5935-00-655-5125	1	2.20
10.	Miniature Case	Aluminum 4 x 2.5 x 1.6 in	1	0.69
11.	Ear Impression Mix **	Kits	1 unit	8.45 Est.
12.	Custom Ear Insert **	Silicone or equivalent	1 or 2 each	8.00 (est.)

* These parts were used in successful modifications; equivalent items are acceptable.

** Available from a reliable vendor or manufacturer. Note that the liquid "setting solution" in the impression mix kits usually has a shelf life of about 6 months.

TABLE 2

SOUND ATTENUATION VALUES OF THE H-133 HEADSET MODIFIED WITH THE CUSTOM MOLDED EARPLUG

	TEST FREQUENCIES (Hz)								
	125	250	500	1000	2000	3000	4000	6000	8000
MEAN ATTN (dB)	29	34	38	41	47	52	55	45	41
MEAN MINUS 2 σ ATTN (dB)	16	22	26	31	35	37	42	35	29

SINGLE NUMBER ATTENUATIONS IN dB FOR DIFFERENT C-A VALUES

	C-A VALUES				
	-2 thru 0	1 thru 3	4 thru 7	8 thru 12	13 and up
ATTN (dB)	31	28	25	21	16

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